LAB DAY 2017

The best of DoD innovation in one place

Lab Day 2017 will feature more than 100 displays highlighting selected technologies from the laboratories and engineering and warfare centers.

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Army

Anti-Access/Area Denial (A2/AD)

ERDC

The U.S. Army Engineer Research and Development Center (ERDC) is collaborating with the U.S. Air Force, Army, Marine Corps, Office of the Secretary of Defense (OSD), Combatant Commands (COCOMs), and Transportation Command (TRANSCOM) to solve significant challenges impeding the ability for planners, analysts, and operators to dominate in an Anti-Access/Area Denial (A2/AD) environment.

These A2/AD challenges must be overcome through simultaneous force projection and sustainment of numerous maneuver units via multiple, distributed, austere, and unexpected penetration points, landing zones, and ports. In pursuit of this strategy, the ERDC is developing and demonstrating technologies for the planning and conduct of entry and sustainment operations with nonexistent, damaged, or destroyed infrastructure.

ERDC's research enables Force Projection in A2/AD environments by providing expedient engineering solutions that negate the enemy's attempt to deny entry into the theater and mobility across the battlefield. Some technologies include:

- Unmanned vessel configured for fly-away deployment to rapidly assess damaged port/pier facilities
- Inexpensive Unmanned Air Vehicles (UAVs) for near-shore coastal recon prior to amphibious landings

Figure 1 Anti-Access/Area Denial unmanned vessel configured to rapidly assess damaged port/pier facilities (A); UAV for near-shore coastal recon (B); terrain surfacing kits for UAS landing strip (C)

- Airfield Damage Repair (ADR) technologies optimized for Army Airborne and Air Force Engineer operations in contested theaters
- Terrain surfacing kits for Unmanned Aircraft Systems (UAS) landing strips, helicopter landing zones, and logistics over-the-shore operations
- Remote monitoring of critical assets and bridge conditions using infrasound
- Global 15-day forecast of stream flow volumes and velocities to inform gap-crossing mission plans
- Battlefield sensors for operational engineer reconnaissance, assessment, and planning
- Decision-support tools for remote infrastructure assessment and strategic level planners.

The evolving A2/AD requirements and Joint Service priorities are strongly pointing to the need to rapidly assess, repair, and construct ports of debarkation under A2/AD constraints. The Future Force requires the ability to rapidly assess and establish multiple distributed aerial or sea ports of debarkation (A/SPoDs) to achieve overmatch with reduced manpower and logistics in these contested environments. These expeditionary capabilities will help ensure the most economical overmatch against the new threats, even with a leaner fighting force.

I-Portal Portable Assessment System (PAS)

MRMC

“TBI Research in Motion”

The I-Portal PAS display is a virtual reality headset connected to a computer program, which, in turn, reads a series of oculo-motor pathways to determine if the subject has sustained a traumatic brain injury, displaying the results (and the subject’s eye movements) on the attached computer screen. This product was developed in part by the U.S. Army Medical Research and Materiel Command’s Combat Casualty Care Research Program and Pittsburgh, Pennsylvania-based company Neuro Kinetics, Inc. Military leaders hope that this technology, with its ability to

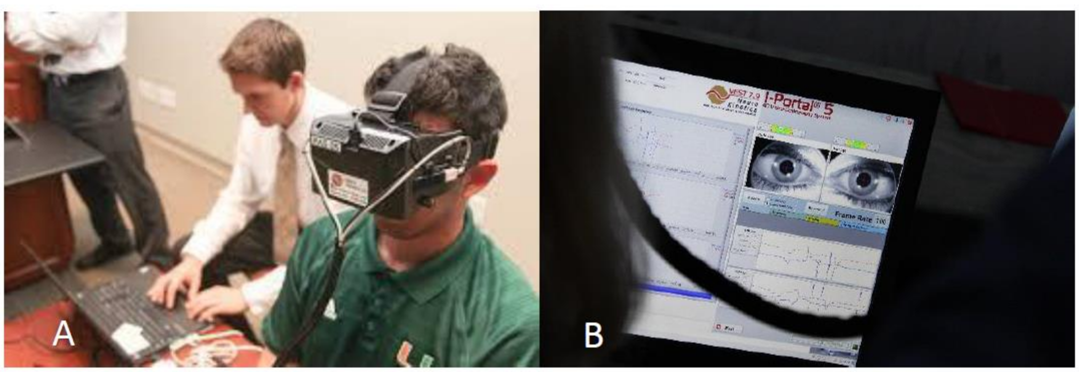


Figure 2 I-Portal Portable Assessment System headset (A) and “eyes” printout (B)

diagnose head injuries in real time, will lead to more accurate and immediate head injury diagnoses among warfighters both on and off the battlefield. Given that the DoD has confirmed more than 350,000 instances of traumatic brain injury across all branches of the U.S. military since 2000, developing a noninvasive tool to quickly and correctly diagnose head injuries is paramount to the future and continued health of the U.S. warfighter.

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA)

MRMC

"Controlling Hemorrhage, Saving Lives"

The Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) display is a three-dimensional plastic tabletop display featuring a hands-on element allowing users to physically inflate the small, catheter-tipped balloon used by surgeons to stop severe bleeding in several

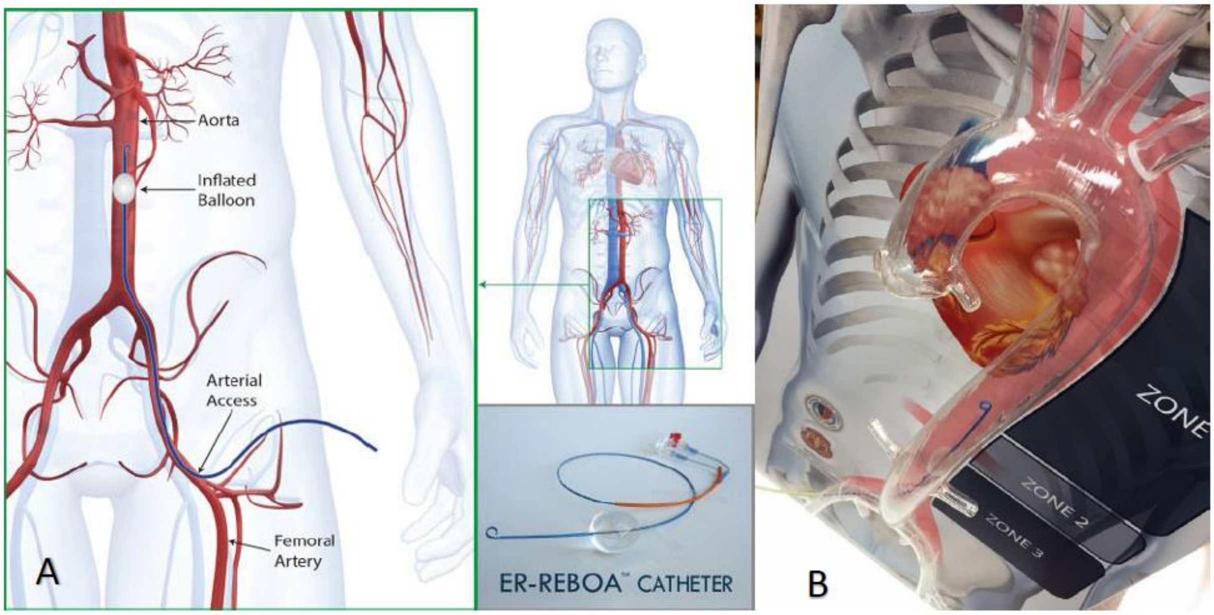


Figure 3 Resuscitative Endovascular Balloon Occlusion of the Aorta diagram (A) and photo (B)

sections of the human truncal region. The REBOA itself is a minimally-invasive technique using that same balloon-tipped catheter to temporarily occlude large vessels in support of hemorrhage control. Hemorrhage leads to cardiovascular collapse and death unless blood flow to the heart muscle and brain is maintained. For patients with truncal hemorrhage, this tool can help maintain blood flow to these critical organs until the hemorrhage can be definitively controlled via surgery. Until REBOA, resuscitative aortic occlusion required an invasive surgical procedure that resulted in high mortality and significant resource usage. The FDA approved the clinical application of REBOA in late 2015 under the brand ER-REBOA. This tool supports active warfighters and was developed by the U.S. Army Medical Research and Materiel Command's Combat Casualty Care Research Program.

Autonomous Systems—Manned/Unmanned Teaming (MUMT)

RDECOM-ARL

On the future battlefield, intelligent robots will be ubiquitous Soldier teammates. Future intelligent systems must conduct operations in challenging, militarily relevant environments; operate in concert with Soldiers and commanders; collaborate with other intelligent systems; and make decisions within and beyond human operational tempo. The U.S. Army Research Laboratory (ARL) is performing the underpinning science that will take robots from tools to teammates. This research supports DoD offset strategy and MUMT research thrusts.

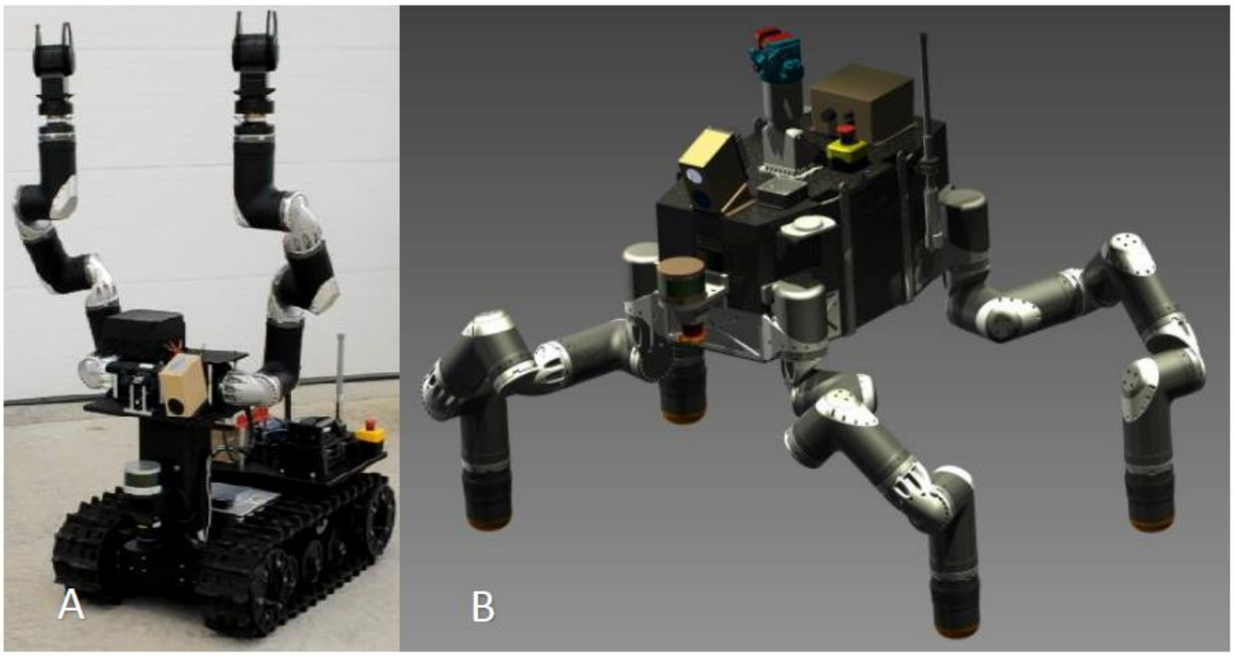


Figure 4 Army Research Lab's RoMan (A) and RCTA Robosimian (B)

The Autonomous Systems- Manned/Unmanned Teaming technology will highlight the basic and applied research being conducted in the Robotics Collaborative Technology Alliance (CTA), Micro Autonomous Systems and Technology (MAST) CTA, and ARL internal program.

Researchers will emphasize the unique challenges relating to the military mission and highlight how this work differs from the research in the other services. ARL subject matter experts (SMEs) propose three components to their demonstration that will highlight the research in autonomous systems, preceded by a brief program overview:

- ARL autonomous systems program overview to include videos of research and experiments that cannot be demonstrated due to time, space, and security constraints.
- ARL employees and collaborators from the Robotics CTA, General Dynamics Land Systems (GDLS), will demonstrate a robotic platform for autonomous manipulation in unknown environments. The RoMAN platform will perform autonomous manipulation of heavy objects in the booth.

- ARL employees and collaborators from the Robotics CTA, GDLS and Jet Propulsion Laboratory (JPL), will demonstrate a robotic platform for autonomous mobility in unknown environments. The RoboSimian platform will perform small-scale maneuvers in the booth.
- ARL employees along with collaborators from the MAST CTA will demonstrate robotic behaviors through videos of robots performing autonomous navigation, mapping, and exploration in complex, militarily relevant environments.

Micro-Autonomous Systems and Technology (MAST)

RDECOM-ARL

The Army Research Laboratory's MAST Collaborative Technology Alliance (CTA) is developing the underpinning science to enable palm-sized and smaller, aerial and ground mobile autonomous robotics technology. The operation vision for the systems is to move with or out in front of the Soldier or Squad as the team moves through urban and other complex environments.

The primary objective is to conduct intelligence, surveillance, and reconnaissance (ISR) operations to provide increased and extended reach situational awareness at the squad level. Army operations will take systems indoors, outdoors, or underground and through structured and unstructured environments with little to no access to GPS, a priori maps, or assured communications. Systems are also viewed as potentially attritable while being required to work collaboratively at operational tempo and deal with uncertainties in the environment and their own state estimation to maximize their value to the soldier.

Figure 5 MAST demonstration

This vision drives the major research themes and objectives of the Alliance to advance fundamental science and technology across three cross-cutting research thrusts: mobility, control, and energetics; sensing, perception, and processing; and communication, networking, and coordination. This research alliance is a collaborative partnership between a consortium of top university researchers and Army scientists and engineers and has led to several significant accomplishments. Key advancements under the program have:

- Increased operational tempo and methods for rapid deployment of autonomous systems
- Improved the capacity of systems to operate in increasingly complex environments
- Significantly decreased the scale demonstrating Soldier portable autonomous systems
- Demonstrated collaborative behaviors for heterogeneous systems
- Developed gust tolerant and aggressive maneuver and controls leading to robust behaviors such as perching and recovery for many surfaces
- Validated and increased the sophistication of physics-based computational fluid dynamics (CFD) simulation tools for MAST scaled and highly maneuverable flying platforms.
- Discovered and realized many bio-inspired approaches to increased efficiency and maneuverability in complex ground terrain
- Advanced the state of the art in size, weight, power, and algorithm efficient sensing and communication hardware concepts.

The program has been demonstrating the art of the possible to inform and enable next generation autonomous systems since 2008. This year will mark the end of the program.

R&D for Medical Simulation and Training

RDECOM-ARL

The Medical Simulation and Performance (MSP) Branch is dedicated to improving the efficiency and effectiveness of medical training. This requires collaboration with the training community across all levels of care, from point of injury through advanced clinical support. MSP benefits from close working relationships with various stakeholders, including the Center for Prehospital Medicine, Army Medical Department Center and School, and Defense Health Agency, among others. By engaging stakeholders to identify training gaps, MSP researches, develops, and applies innovative technologies and measures their effect on human performance. From basic research through advanced development, MSP is driven to transition new knowledge to the community through publications, and has a history of transitioning proven technologies to the force, improving medical training throughout the continuum of care.

According to Tactical Combat Casualty Care (TC3) guidelines, the three major causes of preventable death in combat are severe hemorrhage, airway obstruction, and development of tension pneumothorax. The implementation of TC3 principles has led to a reduction in the number of casualties in recent conflicts. Advancing medical training and simulation technologies has a direct impact on the number of lives saved on the battlefield. The innovative technologies developed under our research efforts directly support TC3 training for first responders.

Other efforts directly address training gaps identified by the user community. One such effort is a prototype lower leg fasciotomy trainer. A fasciotomy is a life-saving surgical procedure that is common in prolonged field care. It requires

high surgical proficiency and a deep understanding of anatomy, yet there are no cost-effective simulators to train it. Initial user tests for this new low-cost, realistic model suggests further development will fill this gap.

Figure 6 R&D Medical Simulation and Training

Third Arm—Lightweight Exoskeleton for Weapon Stabilization

RDECOM-ARL

The U.S. Army Research Laboratory (ARL) is developing a prototype body-worn weapon mount referred to as the "Third Arm." The Third Arm is a passive mechanical appendage that interfaces with a Soldier's protective vest and counterbalances the weight of weapons and other tools. The Third Arm can be connected to the front or the back of the vest, the MOLLE (MOdular Lightweight Load-carrying Equipment) webbing, or an insert that fits into the armor-plate pocket. The Third Arm connects to the Picatinny rail on the top section of the rifle, allowing it to work with various weapons. This device enables a complete counterbalancing of a weapon or tool by redistributing the weight onto the torso of the Soldier using a simple spring element. The configuration lets the user carry and handle a wider variety of weapons and tools, as well as one-handed operation of a rifle for unconventional aiming postures such as in defilade. Additionally, the Third Arm provides a framework to build a recoil-dampening system. The Third Arm is manufactured primarily using high-strength, lightweight carbon-fiber composite, and the prototype weighs less than four pounds.

Figure 7 Third Arm demonstration

The Army is continually seeking to increase the lethality of the dismounted Soldier without increasing their burden. Increasing weapon kinetic energy can increase lethality, but often also increases weapon weight, recoil, noise, and signature. Stabilizing the weapon through the use of a lightweight device such as the Third Arm offers multiple pathways to increase lethality: the Soldier can hold the weapon more steadily and for a longer period with reduced arm fatigue, and the Soldier can use higher-energy weapons because the Third Arm redistributes the extra weight and recoil. The Third Arm could improve marksmanship and reduce fatigue, particularly for shoot-on-the-move and close-quarters combat scenarios, where there is no environmental support for the shooter.

Warrior Injury Assessment Manikin (WIAMan)

RDECOM-ARL

The WIAMan is the world's first crash test dummy for use in under-body blast testing. The WIAMan anthropomorphic test device (ATD) is purpose-built for military use in Live-Fire Test and Evaluation with a fully functional prototype scheduled for delivery in 2018. The WIAMan ATD replicates today's 50th percentile male Warfighter, and is the most durable and human-like ATD for theater threat type loading. The manikin's sophisticated biofidelity and robust sensor design provides an unmatched level of accuracy determining the potential effects of blast on Soldiers in new vehicle systems. The WIAMan will be crucial to Warfighter readiness by optimizing and improving the protection and survivability of ground vehicle systems; evaluating the effects of under-body blasts on mission-critical tasks; and quantifying the risk to the Warfighter, helping to inform vehicle and personal protective equipment design to reduce the number of Warfighters killed in action and promote quality of life outcomes. Partnerships within the government, industry, and academia will produce a full WIAMan capability to include an ATD; a Finite Element Model; and software-based injury library and analysis techniques. The WIAMan exhibit will include multiple opportunities to see and touch the WIAMan test manikin alongside the Hybrid III, the legacy crash test dummy developed by the automotive industry in the 1970s; view videos of the WIAMan Finite Element Model and under-body blast testing with the WIAMan and Hybrid III dummies; and examine 3D prints of sample injuries due to under-body blast.

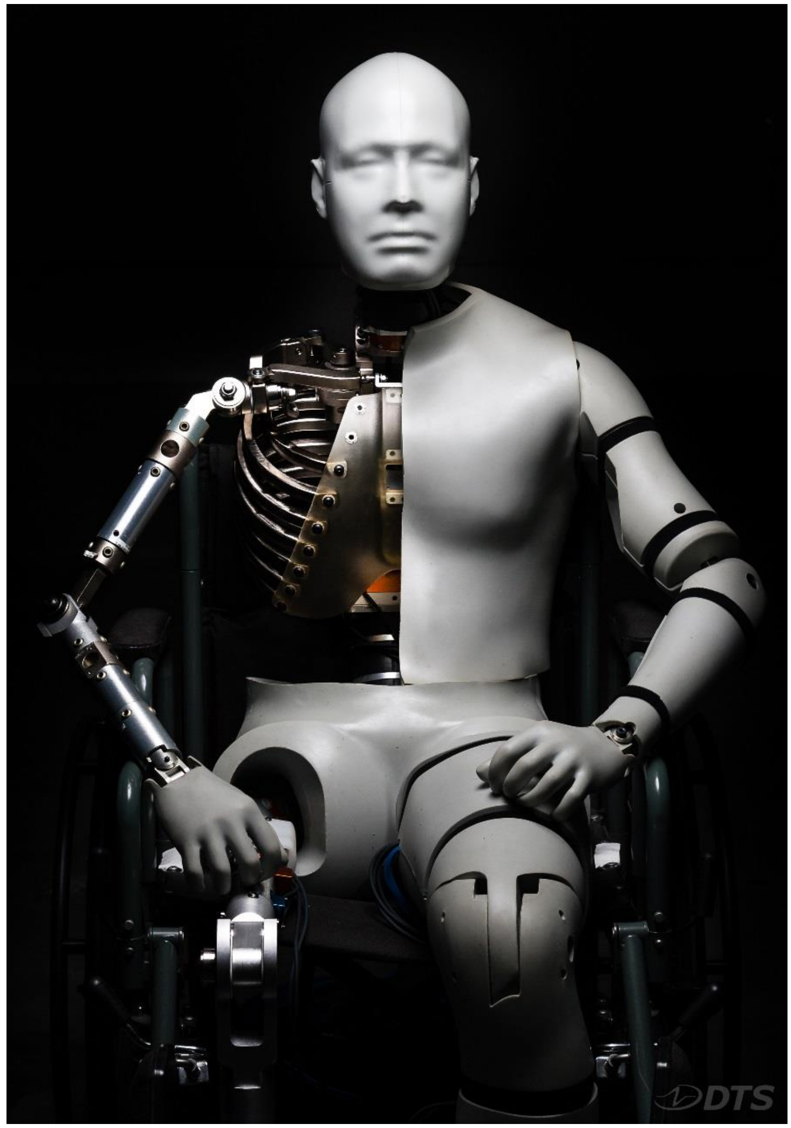


Figure 8 Warrior Injury Assessment Manikin

Dismounted Soldier Power

RDECOM-CERDEC

Current power generation solutions do not offer the ability to generate, recharge, detach, and swap power sources and therefore do not enable multi-day, self-sustainment in expeditionary operations. Large quantities of various types of batteries are required and place significant logistics and weight burden on the Soldier. Power and energy technologies are critical enablers and underlying themes to “Winning in a Complex World.” Future mission success is based upon the ability to operate with the needed power and energy resources in expeditionary environments.

The exhibit will demonstrate innovative portable power solutions and present a synopsis on latest advancements in (1) control standards and matrix architectures for distributed power systems; (2) energy predictive applications and optimization tools for power management; and (3) wireless power transmission. These solutions enable high penetration of renewable energy technologies and ad-hoc arrangements, minimize wasted power, and significantly reduce the various types, quantities, and weight of batteries Warfighters must carry to support a mission.

These new technologies also enable sustainment of remote dismounted and/or expeditionary base camp operations under austere conditions, therefore increasing readiness and lessening dependence on the logistics trail for power and energy support. The portable power and energy technologies that will be on display are conformal wearable power sources (battery and fuel cell), energy harvesting devices (high-efficiency solar panels and kinetic components) and intelligent power management. Any Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) device that is an integrated part of either the Nett Warrior system or a platform operating within a base camp will benefit from the use of these technologies.

The display will consist portable power technologies that visitors can experience first-hand. One monitor in the background will be run short vignettes of power technologies and the other monitor will demonstrate Energy Informed Operation capabilities.

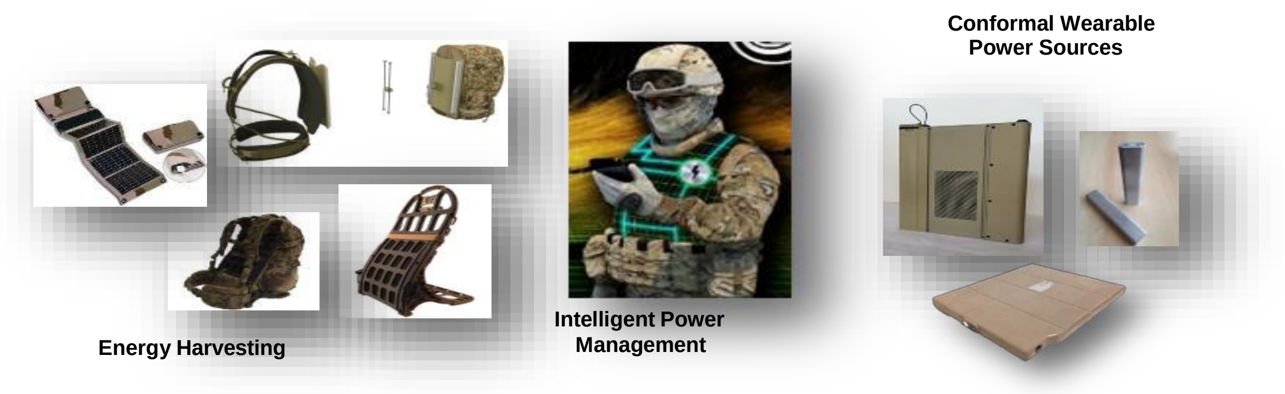


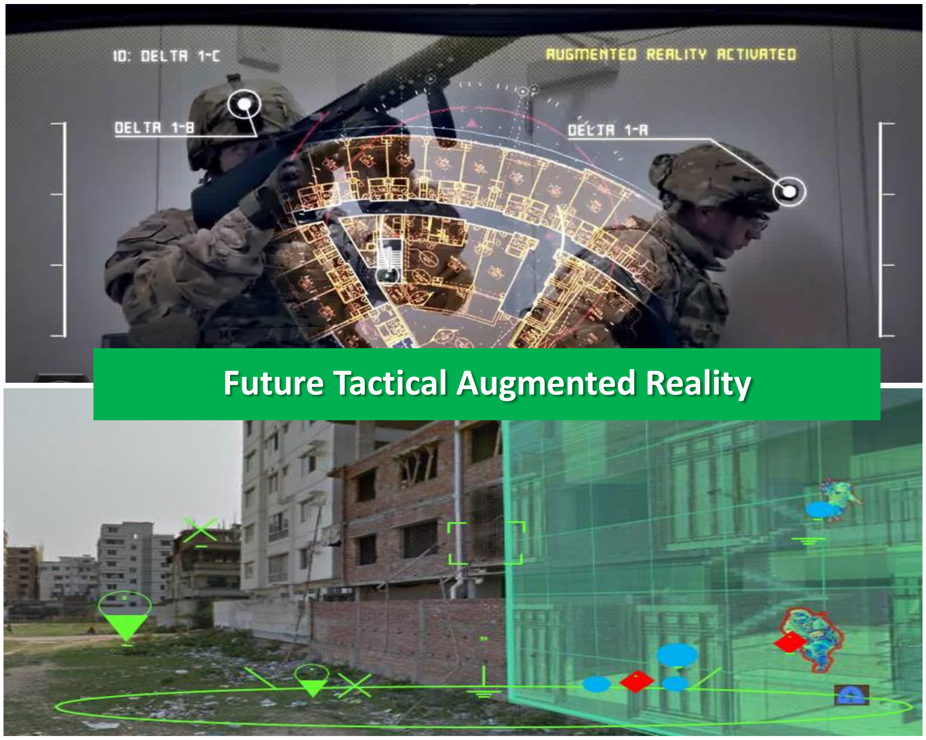
Figure 9 Dismounted Soldier Power

Tactical Augmented Reality

RDECOM-CERDEC

U.S. peer and near-peer adversaries are working aggressively to achieve near-match in Intelligence, Surveillance, and Reconnaissance (ISR) capabilities. The rapidly expanding number of urban populations and shift in conflict to more complex environments and multi-domain battlefields demand the need to improve our preparation for military operations in increasingly complicated battlespaces.

U.S. Army CERDEC, ERDC, NSRDEC, and ARL are working together to develop innovative technologies that provide tactical augmented reality for its warfighters, a leap-ahead capability that delivers real-time, context-aware data overlays.



Tactical augmented reality will revolutionize the way our Soldiers perceive and understand the battlespace, allowing them to achieve a common operating picture between all elements in the field. Tactical augmented reality provides sensor imagery with integrated mapping, navigation, and 3D surface models for greatly enhanced operational maneuver and fires. This capability increases the Soldier's ability to maneuver the battlefield and enhances survivability in dangerous operations. These technologies will enable our warfighters to make and consolidate disproportionate gains against an adversary relative to the unit size and the adversary's operations tempo.

At DoD Lab Day, CERDEC will (1) demonstrate a current prototype tactical augmented reality system, revolutionary component, and system-level technologies that will enable next generation tactical augmented reality capabilities and (2) show a video detailing the game-changing future of tactical augmented reality for our warfighters.

Figure 10 Tactical Augmented Reality

High Energy Laser Technology Development and Demonstration

USASMDC/ARSTRAT

In the past few years, diode-laser technology advances have made solid-state High Energy Laser weapon systems feasible. The Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) is developing the High Energy Laser Tactical Vehicle Demonstrator (HEL TVD) as a pre-prototype system to address Indirect Fire Protection Capability Increment 2 – Intercept (IFPC Inc 2-I) objective requirements. The IFPC is designed to protect warfighters from rocket, artillery mortar (RAM), and unmanned aerial system threats at fixed/semi-fixed sites. The HEL TVD will consist of a 100 kW-class laser projected through a precision pointing, high-velocity target tracking beam control system. The HEL TVD will demonstrate counter-RAM (C-RAM) and counter-Unmanned Aircraft Systems (C-UAS) capability in FY22. Key knowledge points for the HEL TVD are being provided by the High Energy Laser Mobile Test Truck (HELMTT), a heavy expanded mobility tactical truck-based system. The HELMTT has demonstrated the ability for a 10-kW laser system to defeat small-caliber mortars and UAS in relevant environments. Later this year, a 50 kW-class laser will be integrated into the HELMTT and a C-RAM/C-UAS demonstration will be conducted in late FY18 to provide knowledge points for the HEL TVD development. USASMDC/ARSTRAT has also began working the Fires Center of Excellent to provide warfighters with hands-on experience with HEL systems. The Mobile Experimental High Energy Laser (MEHEL), a

Stryker-based HEL system, has shot down UAS. In April 2017, for the first time soldiers successfully operated the MEHEL at the Maneuver Fires Integration Experiment. The MEHEL is providing risk-reduction for a potential combat platform-based HEL system that could maneuver with brigade combat teams.

Figure 11 High Energy Laser Mobile Test Truck (HELMTT)

Navy

Adaptive and Reconfigurable Radio Frequency (RF) Technologies

The combination of increased RF to mm-wave system density on naval platforms and enhanced red-force capability in these frequency ranges necessitates that future Navy transceivers are highly maneuverable and resistant to interference when using the electromagnetic spectrum.

Continued dominance of the electromagnetic spectrum demands transceivers with the capability to rapidly switch between a variety of operating modes while mitigating both co-site and adversarial interference.

In driving toward this goal, the Naval Research Laboratory (NRL) is developing new switch, limiter, and filter technology for tomorrow's naval systems. The switches use chalcogenide-based phase-change materials that exhibit a thermally-actuated, reversible, and nonvolatile transition between amorphous and crystalline phases that dramatically changes the material's electrical and optical properties.

These switches can operate in cryogenic temperatures, are naturally resistant to degradation in radiation environments, and operate well at mm-wave. Additionally, NRL is developing techniques to co-design filters and analog electronics. These techniques enable reconfigurable filters and multiplexers that autonomously respond to interference without any control signals or digital processing of the spectrum, enabling future transceivers to operate more optimally in contested spectral environments.

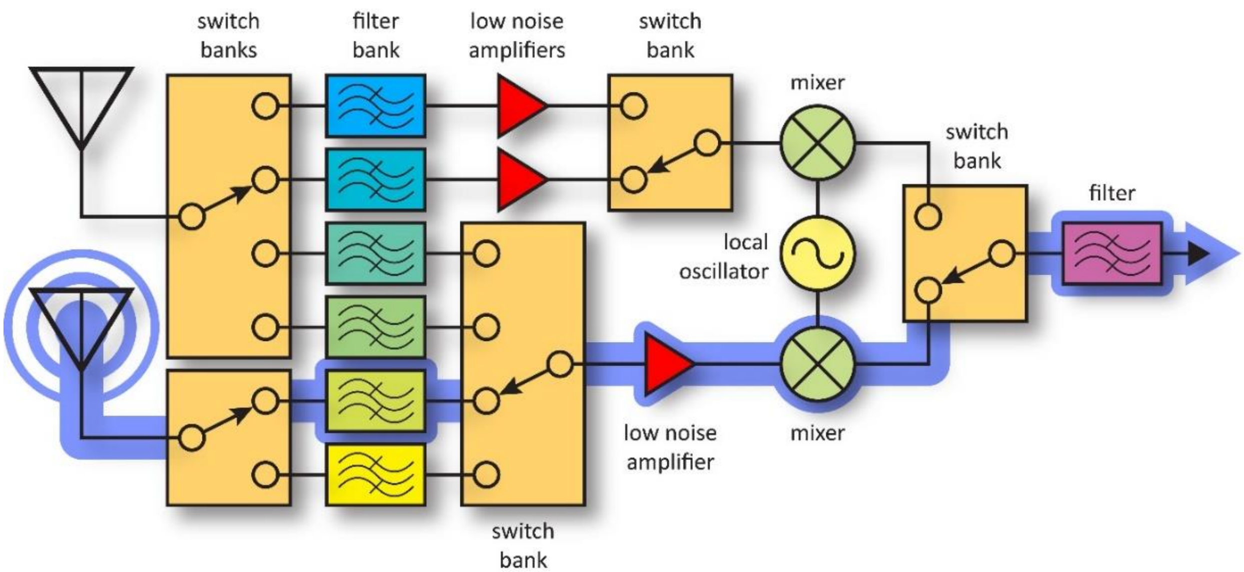


Figure 12 Adaptive and Reconfigurable Radio Frequency (RF) Technologies

Combatant Craft and Unmanned Surface Vehicles

Naval Surface Warfare Center (NSWC) Carderock Combatant Craft Division (CCD) is the Navy and DoD's center for excellence for manned and unmanned boats and combatant craft total systems engineering, providing craft technology and design, craft systems integration, science and technology/research and development (S&T/R&D), acquisition support, and life-cycle engineering. CCD aims to maximize warfighter performance, minimize total ownership costs, and smartly manage risk. CCD maintains expertise in naval architecture, hull, mechanical, electrical and electronics systems design and engineering, survivability, transportability, human systems integration, test and evaluation, logistics, and life-cycle management. CCD supports more than 10,000 boats, craft, and life rafts worldwide.

The CCD exhibit will highlight current and future efforts for a range of purpose-built and re-purposed manned and unmanned combatant craft contributing to our future warfighting needs for the Navy and Marine Corps. Collaborations with other DoD partners will be illustrated. Ongoing Carderock Combatant Craft Unmanned Surface Vehicles (USVs) S&T/R&D efforts will be presented in a variety of static displays. Video and information about the Stiletto maritime demonstration platform will also be available. A man-portable USV craft will be on display.

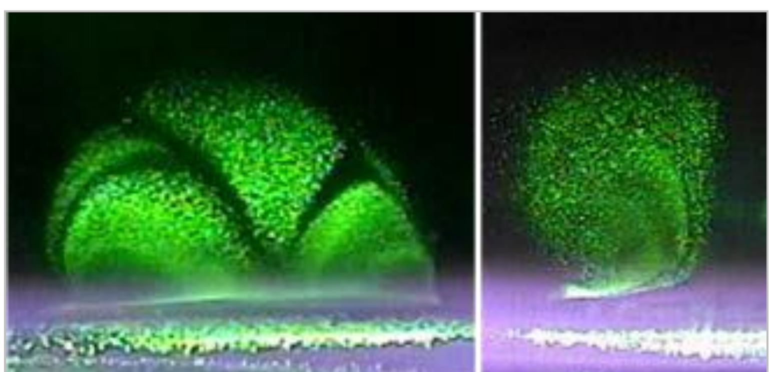
Counter – High Energy Laser Lethality

High-energy lasers are an emerging weapon with a very different damage mechanism than traditional kinetic weapons. The high-energy laser provides naval platforms with a highly effective and affordable defense capability against many surface and air threats, future antiship cruise missiles, and swarms of small boats, and is an effective complement to using expensive missiles against high-density, inexpensive targets.

Figure 13 High energy laser

Dusty Plasmas

NRL has conducted research in the study of the effects of dusty plasmas—charged dust particles that can occur naturally in the mesosphere and can improve hypersonic and reentry vehicles and GPS navigation. Dynamic dusty plasmas are visually striking to observe. They have potential for opening blacked-out



Charged microparticles levitating in a plasma discharge. Dynamic particle motion is observed using laser illumination.

communications channels for hypersonic and reentry vehicles and helping to understand charge neutralization issues in 3-D printing processes.

Figure 14 Dusty Plasma particles

Joint Service Explosive Ordnance Disposal (JSEOD) Unmanned Systems

The Naval Surface Warfare Center Indian Head EOD Technology Division (NSWC IHEODTD) serves as the Technical Direction Agent (TDA), Design Agent (DA), Acquisition Engineering Agent (AEA), and In-Service Engineering Agent (ISEA) for the Joint Service EOD (JSEOD) unmanned systems programs of record managed by Expeditionary Missions Program Management Office (PMS 408). The Man Transportable Robotic System (MTRS) program has fielded more than 3,000 systems to theater since 2006. Joint Service EOD forces worldwide have used these systems extensively in the execution of EOD missions. The unmanned ground vehicles (UGVs) fielded as part of the MTRS program, the MK1 (Packbot) and MK2 (Talon), provide JSEOD operators the ability to perform EOD operations at a safe standoff from explosive threats. Since their initial fielding, several upgrades and modifications have been developed, integrated, tested, and fielded for the MTRS platforms, further increasing the capabilities of JSEOD forces. In the future, the Advanced EOD Robotic System (AEODRS) program will field a Family of Systems (FoS) based on a common architecture, enabling interoperability across increments within the family as well as rapid development and integration of emerging unmanned systems capabilities into the AEODRS platforms.

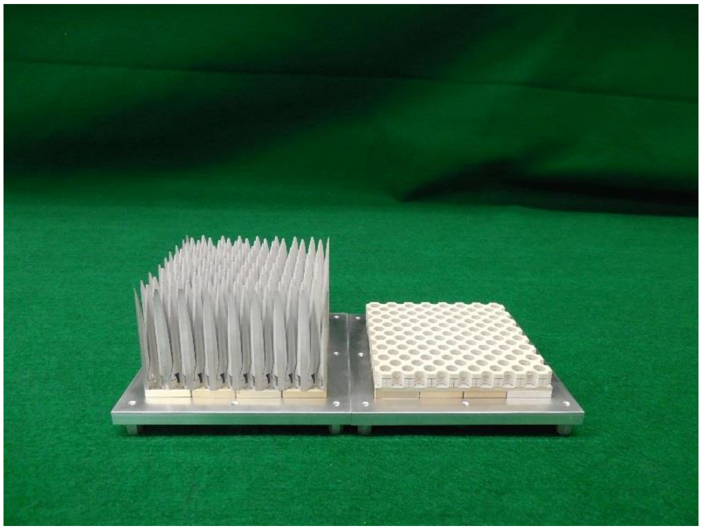


Figure 15 Ultra-wideband Phased Array Antennas

Low-Cost Ultra-Wideband Phased Array Antennas

Ultra-wideband phased array antennas offer significant cost savings by supporting multi-mission operation with innovative low-cost, high-performance builds. Other benefits include ship real-estate savings, stability in tracking low-elevation observables, and reduced ship target signature.

MIMO Millimeter-Wave Airborne Radars for UAVs

This display depicts a millimeter-wave (mmW) multi-input multi-output (MIMO) radar featuring an irregular array antenna topology optimized for 3-dimensional sensing by low-cost, unmanned aerial vehicles (UAVs). The antenna array consists of a relatively small number of transmit (TX) and receive (RX) subarrays, which vary drastically in size. The array antenna is designed to achieve a high gain at broadside while maintaining the scanning capabilities sufficient for UAV applications in target identification, sense and avoid, terminal guidance, and surface reconnaissance. This design method results in a reduced number of antenna subarrays and therefore a lower cost.

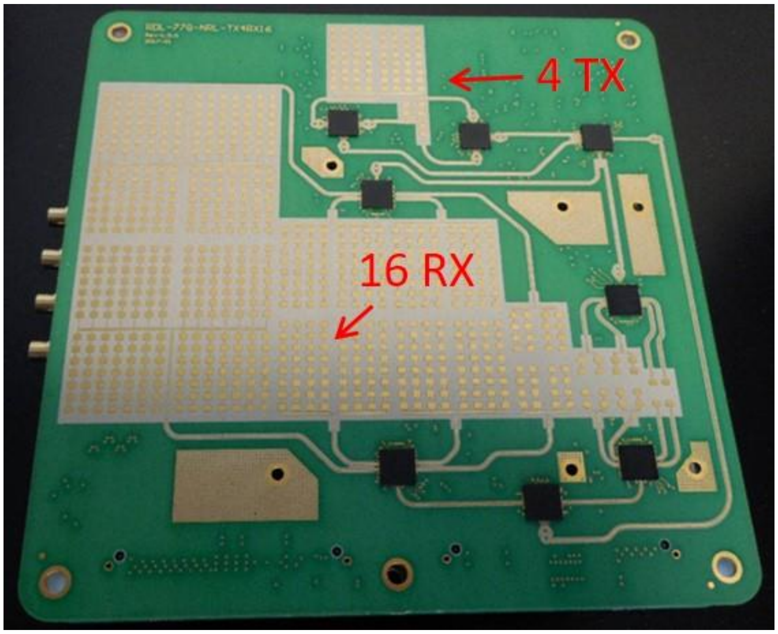


Figure 16 MIMO Millimeter-Wave Airborne Radars for UAVs

Naval Medical Research Center’s Biological Defense Research Directorate Mobile Laboratory

U.S. military medical researchers have focused on how to defend against the threat of biological and chemical warfare since World War I. The deliberate use of biological agents as weapons in the future may require infectious diseases to be classified as battlefield-related and will be extremely serious to the unprepared.

Since 1991, the Naval Medical Research Center’s (NMRC) Biological Defense Research Directorate (BDRD) scientists have studied ways to protect military personnel in the event of a biological attack. The BDRD team members are considered leaders in the field of detection, including hand-held assays, molecular diagnostics, and confirmatory analysis. One of their most visible successes is the first portable laboratory capable of conducting molecular detection in the field.

Figure 17 Biological Defense Research Directorate Mobile Laboratory

This unique laboratory allows military personnel to quickly conduct confirmatory assays to determine whether biological agents are present. The portable laboratory was deployed in Desert Storm/Desert Shield, and similar capabilities were deployed in Operation Iraqi Freedom.

The portable laboratory weighs approximately 1,000 pounds and requires three people to run it. It can be checked onto commercial airlines and requires only gas and motor oil to operate. The portable laboratory holds supplies sufficient to process about 150 samples with polymerase chain reaction (PCR) and enzyme-linked immunosorbent assay (ELISA) testing. It also includes protective gear for the personnel, a generator, a freezer, field lighting, and field uninterruptible power supply (UPS).

BDRD researchers pioneered the development of a small hand-held assay to identify most of the common biological threats, including anthrax, within 15 minutes. These assays were selected by the Joint Program Office for Biological Defense as the standard assay for field identification of biothreat agents.

They also developed real-time PCR-based diagnostics for confirmatory testing. These confirmatory assays are based on the DNA sequence of a particular biological agent. The final step in the confirmation process, definitive testing, can then be done at the NMRC.

The portable laboratory will be on display during DoD Lab Day, May 18. The Navy team will be available to show you how the laboratory works and answer any questions you have.

Navy Railgun

The electromagnetic railgun launcher is a long-range weapon that fires projectiles using electricity instead of chemical propellants. Magnetic fields created by high electrical currents accelerate a sliding metal conductor, or armature, between two rails to launch projectiles at 4,500 mph.

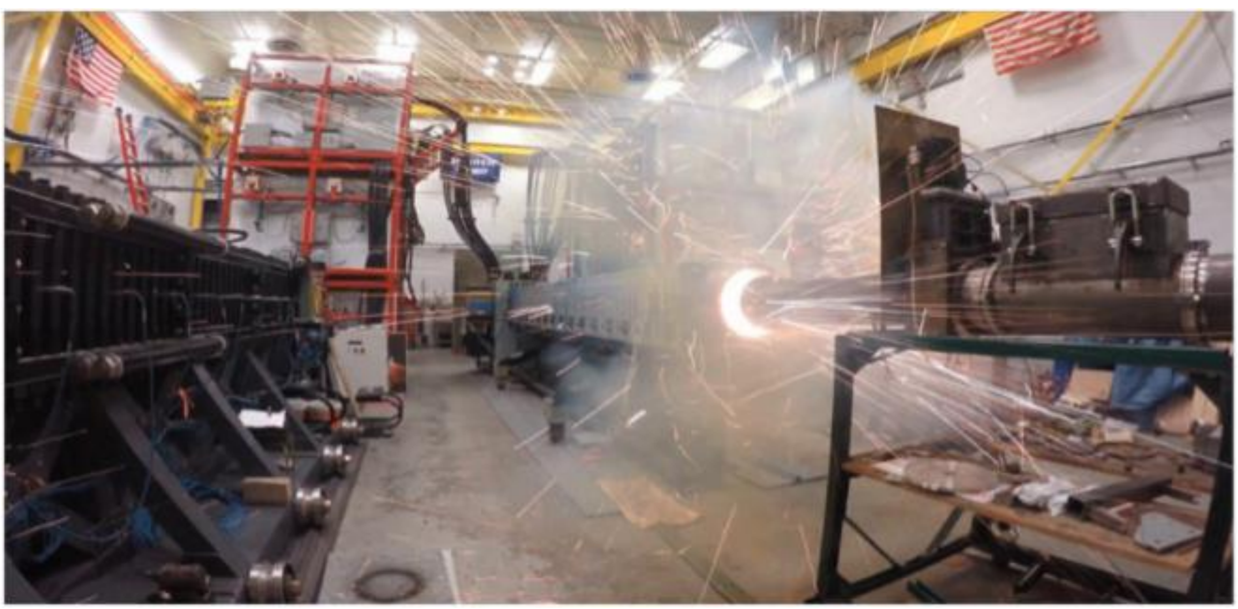
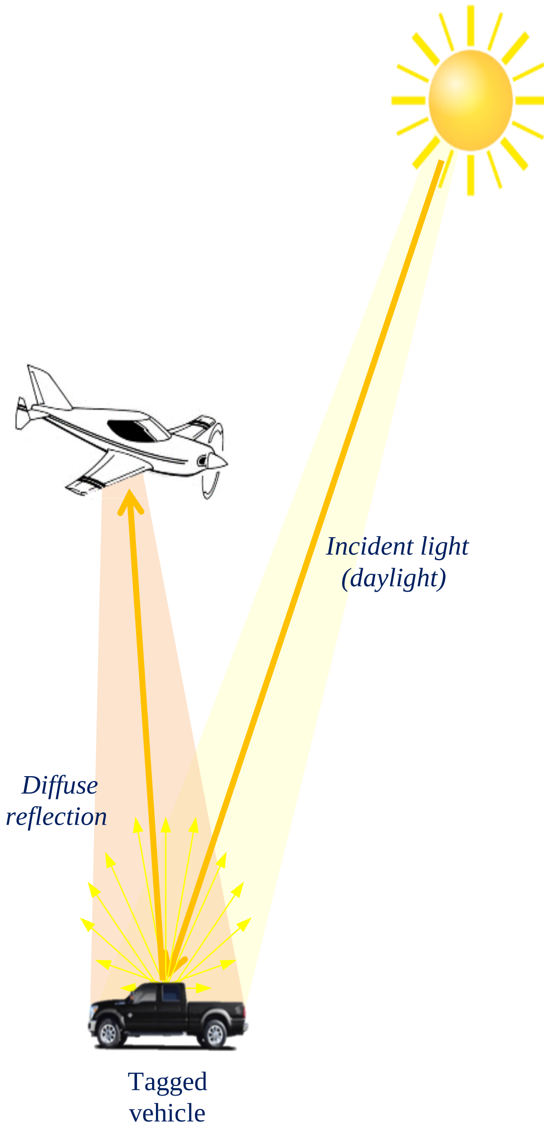


Figure 18 Navy Railgun

Optical Tagging, Tracking and Locating Technology (TTL)



TTL technologies are critical to military operations in complex environments. Tags can be used for a variety of applications, including positive identification of targets from a distance, the ability to distinguish “friend or foe” in cluttered environments to reduce friendly fire incidents, enhanced situational awareness, and reduced times for search and rescue missions.

The NRL has developed novel optical taggant systems materials for tracking moving vehicles/objects or for locating tagged objects in a cluttered environment. The taggant materials are passive (no electronic or optical signals are emitted), and are applied as transparent or color matched coatings or treatments invisible to the naked eye, but easily detected with specifically designed cameras outside the visible region.

The operational mechanism is based on differential absorption and reflection: the tags have been designed with narrow band spectral features, so they have distinctive signatures in regions outside of eye sensitivity and can be detected spectrally while remaining unnoticeable to the naked eye. In addition, tags have been formulated to provide unique spectral barcodes to differentiate multiple targets within a single scene.

Figure 19 Optical Tagging, Tracking and Locating Technology (TTL)

Quantifying Mild Traumatic Brain Injury

To understanding blast operational environment, improve training protocols, reduce mTBI/medical costs, and quantify blast characteristics leading to cellular changes consistent with mild traumatic brain injury, NRL has been designing methods exposing cell cultures to both real and simulated blasts and impacts. The ultimate goal of this research is to lay the foundation for designing and building a helmet that will protect the warfighter in various theaters of operation and be mobile, lightweight, and comfortable.

Figure 20 Surrogate heads in helmets

Rapid Development, Integration, and Testing of Nanosatellites

Nanosatellites are less than a foot long and weigh less than 25 pounds. A common form factor is the CubeSat, which was developed as a low-cost means to teach university students how to develop space systems. CubeSats were originally 10 centimeters on each side and weighed less than a kilogram. That size was later called one unit or "1U," and larger sizes were developed. Now 3U is common and many organizations are building 6U or larger satellites.

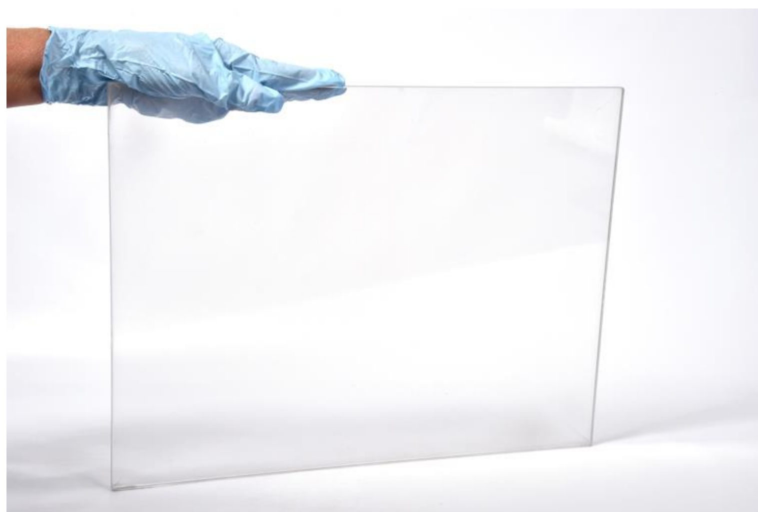
Nanosatellites are launched into orbit when a larger satellite mission has spare room, similar to riding on a space-available airline flight. Once the primary space mission separates from the launch vehicle, the nanosatellites are deployed from a spring-loaded canister. More than 100 were launched in both 2013 and 2014, and hundreds more nanosats are in development by academic, commercial and military organizations.

Space and Naval Warfare Systems Center Pacific (SSC Pacific) is developing a government nanosatellite integration capability called ACTION (Accelerated Capability for Testing and Integration of Nanosatellites) to integrate nanosatellite buses with specialized and classified payloads for military applications and provide a rapid response capability to the warfighter, addressing increasing threats to information dominance in the space domain.

SSC Pacific provides the U.S. Navy and military with essential capabilities in the areas of command and control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR), cyber, and space. A recognized leader in the cyber domain and cyberspace and for autonomous unmanned systems, SSC Pacific is providing the technological and engineering support critical to naval information warfare.

Transparent Biomimetic Armor

Mimicking nature, NRL armor is 25 percent more effective. It enhances warfighter protection while decreasing the load and increasing survivability, mobility, and transportability. This new class of transparent and opaque armors may also be used in windows, windscreens, and lenses for visible and infrared cameras.



The NRL uses a hot press to make spinel into conformable optics, like this flat sheet. “Ultimately, we're going to hand it over to industry,” said Dr. Jas Sanghera, who leads the research, “so it has to be a scalable process.” In the lab, they made pieces eight inches in diameter. “Then we licensed the technology to a company who was able to scale that up to much larger plates, about 30 inches wide.”

Figure 21 Hot press used to make spinel into conformable optics, like this flat sheet

Air Force

Advanced Ordnance Technologies

AFRL's suite of Advanced Ordnance Technologies have, individually, the potential to improve future weapons; together they can truly revolutionize the way weapons are developed. While warheads have become tougher, fuzes smarter, and explosives more powerful, their basic design has remained the same for nearly a century. Maintaining our warfighting edge requires the pursuit of new approaches.

The weaponization of current and future stealth air platforms will require smaller munitions that fit into internal bays to keep the aircraft unseen. In the future, smaller weapons must meet or exceed the lethality of larger, conventional weapons. Additionally, because of limited carriage capacity, future weapons must be capable of in-flight dynamic re-tasking that allows sortie flexibility when encountering diverse targets.

Figure 22 Advanced Ordnance testing

AFRL's Munitions Directorate is developing a suite of integrated technology solutions that will allow for smaller, more effective, and more selective weapons. Selectable or dialable effects technologies will enable the pilot to put the appropriate effect on target, potentially reducing the number of sorties and increasing weapon effectiveness. Additionally, using reactive metals in place of steel in a warhead will allow the case to become part of the energy a weapon releases. This means we may be able to reduce the size of a weapon without decreasing the energy it releases. Nanoenergetic materials show promise in making smaller weapons more effective as well. These energetic materials release energy faster and more efficiently than traditional explosives, meaning they pack more punch in smaller amounts. Finally, additive manufacturing will improve how quickly we can refresh and customize technologies and will allow for the development of unique weapon structures.

These technologies will become more integrated with the opening of the Munition Directorate's new FY17 military construction (MILCON) project, the Advanced Munitions Technology Complex. For the first time, an entire ordnance system (e.g., the warhead case, energetic materials, and fuze) will be developed simultaneously, enabling scientists and engineers to understand how each technology enhances the other.

Advancing Biosensor Development using Synthetic Biology Approaches

Synthetic biology enables revolutionary advances in the development of sensor detection modules and tailorable materials. Highly specific sensor modules have been developed using synthetic biological approaches by partnering across the Department of Defense, other government agencies, academia, and industry. As the field continues to develop, synthetic biology will enable control and processing of information, materials, energy, and advances in human health/medicine. Expanding the sensor elements to more stable biomolecules such as DNA aptamers and peptides will allow more near-term solutions for transition to the field. The team is actively determining current deployment challenges with microbiome signatures to understand and recommend solutions. Supported by the Air Force Office of Scientific Research (AFOSR) since 2006 and OSD in 2017, AFRL has spearheaded biosensor and materials development using synthetic biology approaches for environmental and human performance applications.

Figure 23 AFRL "Band-Aid"

The AFRL team is genetically engineering microorganisms for accurate and sensitive detection of target chemicals and/or biomarkers in a diverse variety of fields such as environmental monitoring, defense, medicine, and safety. The team has been engineering bacteria to sense non-natural chemicals and report these detection events via fluorescent protein production. This work has created sensing elements that respond to molecules such as trinitrotoluene (TNT), industrial contaminants, and cortisol (stress hormone). The process for selecting a sensing element and the subsequent coupling of this sensing element with a functional reporter is critical for applications to human performance and novel material interfaces. The team is working with leaders in synthetic biology, pushing the limits of the "design, build, and test" paradigm to control and coordinate cellular functions—a responsive effort in human performance for the Air Force and DoD.

AFRL is a key contributor participating in the Applied Research for the Advancement of S&T Priorities (ARAP) program on Synthetic Biology for Military Environments (SBME), a collaborative effort among the Air Force, Army, and Navy that applies basic advances in synthetic biology and knowledge to meet unique defense needs and the specific challenges presented in military environments. Out of this effort will come the ability to engineer organisms with sense/respond modules that are relevant in military environments.

Low Cost Attritable Aircraft Technology (LCAAT)

The Low Cost Attritable Aircraft Technology (LCAAT) program is exploring a wide range of technology innovations that will enable a new genre of low-cost UAVs.

These UAVs deliver long-range responsive capability in near-peer environments where forward basing is difficult or prohibited. Because of their low cost, different classes of UAVs will augment current weapons systems with highly tailored/optimized roles for specific mission activities including weapons delivery, finding and locating targets, jamming, or communications. LCAA can fly into highly contested areas ahead of a manned craft. The manned aircraft will thus be supported by UAVs, thereby increasing the engagement abilities in contested areas.

The goal of the LCAAT program is to develop a family of low-cost, attritable UAVs at $3M per unit (based on a purchase quantity of 100 UAVs less payload). The program also focuses on minimizing life-cycle costs with emphasis on operations and sustainment activities that improve turn times while minimizing staffing requirements.

Figure 24 Low Cost Attritable Aircraft Technology Program Unmanned Air Vehicle

The program will use a product line approach distinguished by continual aircraft design and capability refresh to incorporate emerging technologies in a timely and cost-effective manner. LCAA can be manufactured at a high rate, reducing touch labor and ultimately reducing cost. Designed for a narrow requirement suite, engineering and production cycles can be reduced, supporting rapid response to warfighter needs. This approach also eliminates costly depot maintenance as well as the design restrictions imposed when using existing airframes.

LCAA are not built for longevity: acceptance criteria should become less complex, resulting in a quicker production-to-air timeline.

Establishing design criteria that will address the ideal cost-to-quality ratio is the next step in this innovative developmental program.

Machine Learning on a Neuromorphic Computer with TrueNorth Processors

Losing network connection, human control, or access to a ground station in contested areas can lead to mission failure. A warfighter's potential inability to identify targets on synthetic aperture radar (SAR) images is a major disadvantage. This opens a need for a technology that can detect targets and operate without external dependencies.

AFRL has combined machine learning, Neuromorphic Computing technologies, and the IBM TrueNorth processor to meet and reduce the dependency on external factors (networks, ground stations, etc.). The result of combining these technologies is a deep neural network (DNN) application that achieves more than 90 percent accuracy and is 20 times more energy efficient.

Machine learning is a type of artificial intelligence that is able to learn from data and then execute cognitive functions without being explicitly programmed. Using a neuromorphic computer inspired by the working mechanisms of the human brain with sixteen IBM TrueNorth Processors, the machine is able to process electro-optical, infrared, and radio frequency (EO/IR/RF) images and videos while detecting targets that can then be classified.

Figure 25 TrueNorth neuromorphic computer machine learning

This technology will provide warfighters with new capabilities such as enhanced big data analytics, faster target/event recognition, and improved situational awareness. The goal is to allow for more prompt and robust decision making. Applied to UASs in contested areas, this tool offers up to a hundred times better energy efficiencies that enable size-weight-and-power (SWaP), intelligent at-the-edge processing, analytics, and decisions, as well as autonomous intelligence, surveillance, and reconnaissance capabilities when human-out-of-the-loop situations occur.

As this technology advances, we will be able to implement smaller computers into aircraft without losing data processing capabilities. Future applications include attaching these computers to multiple platforms to further enhance capabilities when a network connection is lost or access to a ground station in contested areas is limited.

Self-Protect High Energy Laser Demonstrator (SHiELD)

The Air Force is pursuing laser weapons systems (LWS) along with high-powered electromagnetics to enable operations against adversaries who may try to prevent access to—or deny our ability to operate in—a given area.

Years of study into laser sources, optics, beam control, and power and thermal management supporting systems has enabled laser technology to make significant leaps in performance and maturity. Recent developments in electric solid-state and fiber lasers, designed primarily for tactical engagement, now offer weapons-grade power in compact systems suitable for airborne applications.

Figure 26 F16 in anechoic chamber directed energy facility

The Self-Protect High Energy Laser Demonstrator (SHiELD) Advanced Technology Demonstration (ATD) will prove the readiness of these laser technologies by integrating a podded laser system onto an aerial platform and demonstrating its ability to protect the aircraft. The program will develop and integrate a compact, ruggedized, high-energy laser system onto a tactical aircraft and demonstrate its effectiveness in a complex flight environment for self-defense against threats. The purpose of the SHiELD ATD is to reduce and retire the risk of an airborne LWS in a calculated and precise fashion, meeting and resolving the technical challenges of power-scaling, beam quality, thermal management, and packaging. The flight demonstration is expected to prove that targets can be tracked at sufficient range and speed to be engaged and defeated by the laser. Flight tests should occur in the FY21 timeframe.